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**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2012
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

Prepared For:

**CITY OF HELENA
HELENA, MONTANA**



Hydrometrics, Inc.
consulting scientists and engineers

SEPTEMBER 2012



Hydrometrics, Inc.
consulting scientists and engineers

3020 Bozeman Avenue
Helena, MT 59601
(406) 443-4150
Fax: (406) 443-4155
www.hydrometrics.com

September 20, 2012

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Waste & Underground
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Mr. Martin Van Oort
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

RE: Data Validation and Statistical Evaluation of June 2012 Groundwater Quality Data

Dear Martin,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in June 2012. After receiving approval from Pete Anderson of the City of Helena, I am forwarding a copy of the report "Data Validation and Statistical Evaluation of June 2012 Groundwater Quality Data City of Helena Landfill" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: John Rundquist, City of Helena, without Enclosure
Pete Anderson, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2012
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

Prepared for:

Mr. John Rundquist
City of Helena
City/County Building
316 North Park Avenue
Helena, MT 59623

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

September 2012

TABLE OF CONTENTS

LIST OF TABLES	iii
LIST OF FIGURES	iii
LIST OF APPENDICES.....	iii
1. REPORT OBJECTIVES	1-1
2. SITE DESCRIPTION.....	2-1
2.1 PHYSICAL FEATURES	2-1
2.2 WELL LOCATIONS	2-1
2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY	2-4
2.4 CURRENT ACTIVITIES	2-4
3. SUMMARY OF JUNE 2012 DATA VALIDATION REPORT	3-1
4. STATISTICAL DATA EVALUATION AND COMPARISON	4-1
4.1 DOWNGRAIDENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY	4-1
4.2 INTER-WELL PREDICTION INTERVAL ANALYSIS.....	4-7
4.3 TREND ANALYSIS	4-9
4.4 TEMPORAL CONCENTRATION PLOTS	4-10
4.5 CROSS-GRADIENT DATA EVALUATION.....	4-14
5. IRRIGATION WELL AND DOMESTIC WELL DATA EVALUATION	5-1
6. SUMMARY AND CONCLUSIONS.....	6-1
7. REFERENCES	7-1

LIST OF TABLES

TABLE 2-1. GROUNDWATER VELOCITIES	2-5
TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS FOR THE JUNE 2012 MONITORING EVENT	4-2
TABLE 4-2. COMPARISON OF DOWNGRAIDENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR THE JUNE 2012 SAMPLING EVENT	4-3
TABLE 4-3. COMPARISON OF DOWNGRAIDENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR ALL SAMPLING EVENTS TO DATE.....	4-4
TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS.....	4-8
TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES.....	4-9

LIST OF FIGURES

FIGURE 2-1. VICINITY MAP	2-2
FIGURE 2-2. STUDY AREA AND JUNE 2012 POTENTIOMETRIC SURFACE	2-3
FIGURE 4-1. TEMPORAL TRENDS IN TETRACHLOROETHENE CONCENTRATIONS AT SELECTED MONITORING WELLS	4-11
FIGURE 4-2. TEMPORAL TRENDS IN NITRATE CONCENTRATIONS AT SELECTED MONITORING WELLS.....	4-13
FIGURE 5-1. TEMPORAL TRENDS IN PCE CONCENTRATIONS IN DOMESTIC AND IRRIGATION WELLS	5-2

LIST OF APPENDICES

APPENDIX A	DATA VALIDATION REPORT
APPENDIX B	STATISTICAL ANALYSIS REPORTS

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2012
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the June 2012 monitoring event, summarizes, the data validation results and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.708(12) and ARM 17.50.708(13) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

- Concentrations of PCE are decreasing over time in well EPA-1, the well that has historically shown the highest concentrations, and in compliance wells HL-90-1, HL-99-1, HL-99-2, and HL-99-3; and
- Elevated nitrate plus nitrite as N (nitrate) concentrations exist both upgradient and downgradient of the landfill at similar levels.

These findings are further evaluated in this June 2012 statistical report through an assessment of current concentrations (Table 4-1), a comparison of summary statistics (Tables 4-2 and 4-3), an inter-well prediction analysis (Table 4-4), and an examination of temporal trends (Table 4-5 and Figures 4-1 and 4-2).

2.1 WELL LOCATIONS

Fourteen monitoring wells located around the landfill were included in the June 2012 groundwater monitoring program and are characterized as follows:

- Upgradient wells: HL-90-1, HL-99-1R, HL-99-1A, MPC-1;
- Downgradient wells: HL-90-1 (upgrd), HL-90-1, HL-90-2, HL-90-3, MPC-2, MPC-3, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Down-gradient well: HL-94-1.

As discussed in Section 3.0 and in accordance with the approved sampling and analysis plan (Hydroscience, 2006), fourteen of these wells were sampled during the first sampling event. The locations of these wells are shown in Figure 3-2.

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill were included in the June 2012 groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1 (replaced HL-90-1), HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3.0 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), fourteen of these wells were sampled during the June sampling event. The locations of these wells are shown in Figure 2-2.




 NO SCALE

CITY OF HELENA LANDFILL
 DATA VALIDATION & STATISTICAL
 EVALUATION OF JUNE 2011
 GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE

2-1



CODE	DTWL	MPE	SWL
Jun-12			
-1	17.22	3993.62	3976.40
	47.60	3981.08	3933.48
-1	56.49	3943.01	3886.52
-2	46.97	3950.96	3903.99
-3	61.45	3958.29	3896.84
-1R	60.20	3994.04	3933.84
-2R	34.08	3967.64	3933.56
-3	39.07	3967.38	3928.31
-1	61.32	3943.15	3881.83
-2	89.12	3945.75	3856.63
-3	74.57	3948.05	3873.48
SALLE	8.55	3918.89	3910.34
	66.07	3899.59	3833.52
			*avg last 5
1	23.05	3946.08	3923.03
2	17.49	3936.09	3918.60
3	55.56	3990.14	3934.58



SCALE

0 (In Feet) 800

LEGEND

- 1 ■ PIEZOMETER
- 6 ● MONITORING WELL
- 8 ▲ IRRIGATION WELL
- 10 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

UDY AREA AND JUNE 2012
TENTIOMETRIC SURFACE

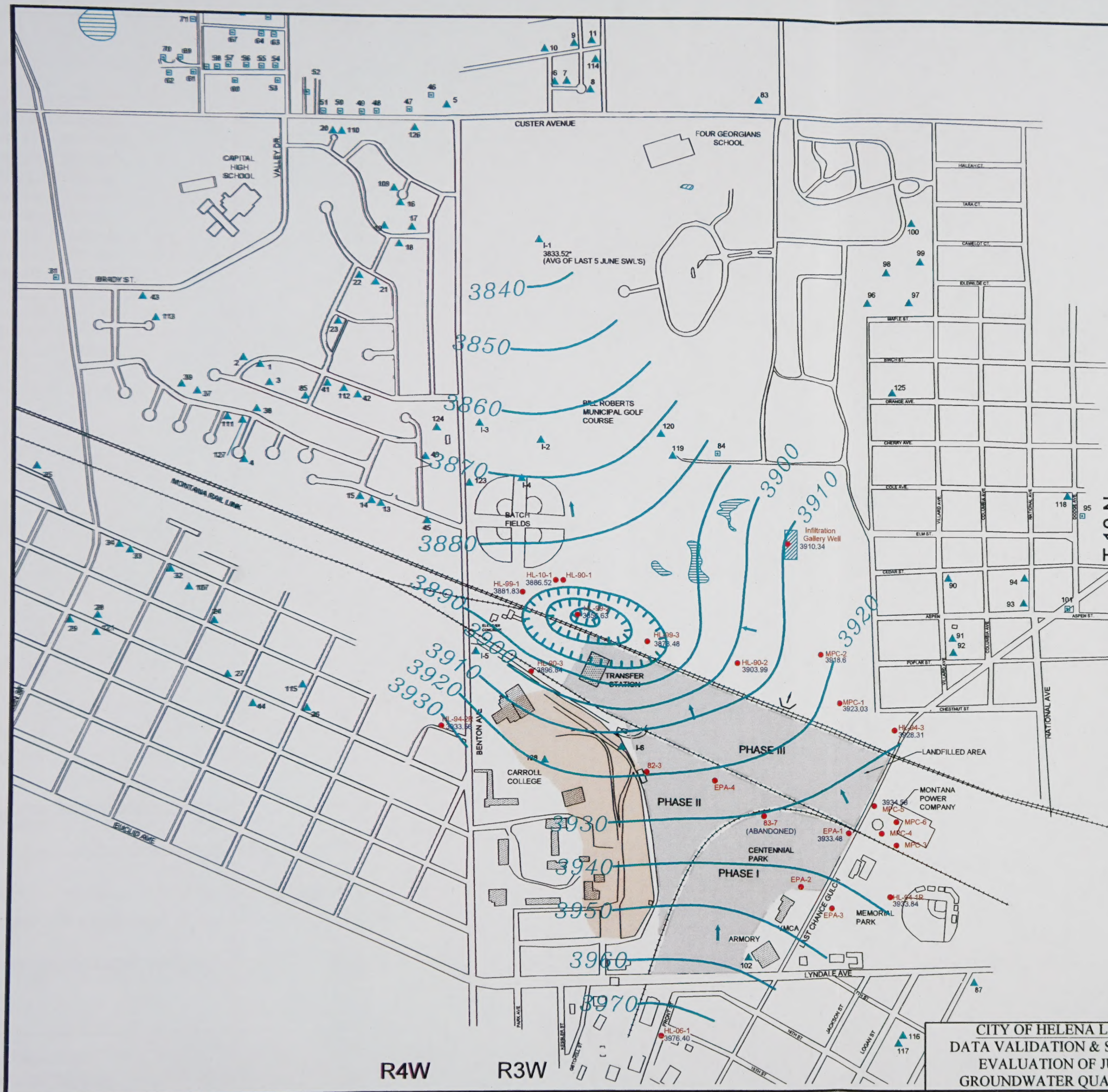
FIGURE

2-2

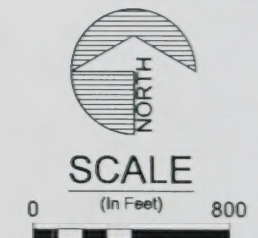
UPDATE TIME: 11:18 AM

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Consulting Scientists and Engineers



SITE CODE	DTWL	MPE	SWL
Jun-12			
HL-06-1	17.22	3993.62	3976.40
EPA-1	47.60	3981.08	3933.48
HL-10-1	56.49	3943.01	3886.52
HL-90-2	46.97	3950.96	3903.99
HL-90-3	61.45	3958.29	3896.84
HL-94-1R	60.20	3994.04	3933.84
HL-94-2R	34.08	3967.64	3933.56
HL-94-3	39.07	3967.38	3928.31
HL-99-1	61.32	3943.15	3881.83
HL-99-2	89.12	3945.75	3856.63
HL-99-3	74.57	3948.05	3873.48
INF. GALLE	8.55	3918.89	3910.34
I-1	66.07	3899.59	3833.52 *avg last 5
MPC-1	23.05	3946.08	3923.03
MPC-2	17.49	3936.09	3918.60
MPC-5	55.56	3990.14	3934.58



LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-3 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- ▨ INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 3900 — POTENTIOMETRIC CONTOUR LINE
- ➔ INFERRED GROUNDWATER FLOW DIRECTION
- ↘ STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF JUNE 2012
GROUNDWATER QUALITY DATA

STUDY AREA AND JUNE 2012
POTENTIOMETRIC SURFACE

FIGURE

2-2

2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in June 2012 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. The potentiometric surface in the area of well HL-94-3 suggests that groundwater flows to the west northwest (Figure 2-2); thus, well HL-94-3 is not considered to be upgradient or downgradient of the landfill. Well HL-94-3 has, therefore, been designated as a “cross-gradient” well.

Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the June 2012 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report “Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill” (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0238 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.705 ft/day.

2.4 CURRENT ACTIVITIES

New modifications to Centennial Park, located over the old landfill, began in June 2010 and continued through the fall of 2012. Construction work included the installation of fill material and some utilities, planting of new grass and trees, and the installation of a new automatic watering system and other park facilities. All modifications to the park were reviewed to ensure the integrity of the landfill cap would be maintained and that the final construction would be even more protective of human health and the environment than the previous construction. All plans were submitted to MDEQ prior to construction. Every

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
EPA-1	2.8	0.0181	0.203
HL-06-1	0.03	0.0257	0.00308
HL-10-1	20	0.0588	4.71
HL-90-2	5.6	0.0334	0.748
HL-90-3	0.03	0.0593	0.00711
HL-94-1R	2.8	0.0110	0.123
HL-94-2R	0.28	0.0570	0.0638
HL-94-3	2.8	0.0102	0.114
HL-99-1	10	0.0431	1.72
HL-99-2	20	0.00677	0.542
HL-99-3	20	0.0677	5.41
I-1	20	0.0235	1.88
Infiltration Gallery	5.6	0.0261	0.585
MPC-1	2.8	0.0170	0.190
MPC-2	2.8	0.0228	0.256
MPC-5	2.8	0.00573	0.0641

effort was made to preserve the existing monitoring wells and the corrective measures previously implemented. During the 2012 summer, the City finalized the landscaping details including the installation of fences throughout the park. The City also worked on optimizing the watering system by encouraging the growth of the grass seed while minimizing standing water on the landfill cap.

3. SUMMARY OF JUNE 2012 DATA VALIDATION REPORT

Fourteen monitoring wells around the landfill, eight domestic wells, one irrigation well and the infiltration gallery well were included in the June 2012 sampling event. Well HL-90-1 was not sampled due to low water levels. The June 2012 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells EPA-1, HL-06-1, HL-10-1, HL-90-2, HL-90-3, HL-94-1R, HL-94-2R, HL-94-3, HL-99-1, HL-99-2, HL-99-3, MPC-1, MPC-2, MPC-5;
- Irrigation well I-4;
- Domestic wells 5, 16, 40, 48, 52, 57, 62, 90; and
- The infiltration gallery.

The June analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells except MPC-2 and volatile organics, semi-volatile organics, and halogenated organics for MPC-2 and all remaining domestic and irrigation wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in June 2012 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, a trip blank, a rinsate blank, and standard internal laboratory QC samples. No parameters were reported as above the reporting limit in the D.I. blank, trip blank, or rinsate blank. The entire data validation report is included as Appendix A of this report. Overall, the City of Helena Landfill data for June 2012 were deemed acceptable for the purposes of the project as outlined in the work plan.

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the June 2012 sample results for the monitoring wells around the landfill; cross-gradient well HL-94-3 is evaluated separately. The infiltration gallery, irrigation well, and domestic wells are also evaluated separately. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called “background”) water quality with summary statistics of downgradient concentrations for June 2012 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the June 2012 sampling event.

The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells sampled during the June 2012 sampling event which have historically shown PCE results above the detection limit of 0.001 mg/L and nitrate results above the MCL of 10 mg/L or with potentially increasing trends were evaluated.

4.1 DOWNGRAIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the June 2012 data and summary statistics in Tables 4-1, 4-2, and 4-3:

- (a) For the June 2012 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (or upgradient) wells: arsenic, selenium, 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylene, m+p xylene and total xylene.

**TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS
FOR THE JUNE 2012 MONITORING EVENT**

Parameter	Downgradient Wells									Upgradient Wells				Cross-Gradient Well	MCL ⁽¹⁾
	HL-90-2	HL-90-3	EPA-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-10-1	HL-06-1	HL-94-1R	HL-94-2R	MPC-5	HL-94-3	
pH (s.u.)	7.4	7.1	6.9	7.1	NM	7.0	7.2	7.1	6.9	7.0	7.3	7.4	6.9	7.5	NA
Specific Conductance (µmhos/cm)	702	1250	1880	1180	NM	1370	966	966	1470	1020	969	899	2830	1030	NA
Sulfate	40	180	150	200	NM	170	120	150	150	140	81	65	590	110	NA
Chloride	28	63	150	66	NM	100	49	50	140	30	31	37	56	100	NA
Nitrate+Nitrite as N	1.05	10.0	16.1	11.8	NM	9.62	6.14	8.8	9.30	4.85	4.02	7.64	31.7	17.8	10
Arsenic (Dissolved)	< 0.005	< 0.005	< 0.005	< 0.005	NM	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.011	< 0.005	< 0.005	0.010
Iron (Dissolved)	< 0.03	< 0.03	< 0.03	< 0.03	NM	< 0.03	< 0.03	0.04	< 0.03	< 0.03	< 0.03	< 0.03	1.46	< 0.03	0.3 ⁽²⁾
Nickel (Dissolved)	< 0.01	< 0.01	0.03	< 0.01	NM	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.10
Selenium (Dissolved)	< 0.005	< 0.005	< 0.005	< 0.005	NM	< 0.005	< 0.005	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	0.010	< 0.005	0.05
Zinc (Dissolved)	< 0.01	< 0.01	< 0.01	< 0.01	NM	< 0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2.0
1,1,1-Trichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0014	< 0.001	< 0.001	< 0.001	< 0.001	0.2
1,1-Dichloroethane	< 0.001	< 0.001	< 0.001	0.0029	< 0.001	< 0.001	0.0021	0.0030	0.0024	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA
Benzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.540	< 0.001	0.005
Bromodichloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0025	< 0.001	< 0.001	< 0.001	0.010
Chloroform	< 0.001	0.0043	< 0.001	0.0018	< 0.001	0.0019	0.0015	0.0022	< 0.001	0.0021	0.017	0.0043	0.0032	0.010	0.07
Cis-1,2-Dichloroethene	< 0.001	< 0.001	0.0012	0.0039	< 0.001	0.0016	< 0.001	< 0.001	0.0022	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0012	0.0014	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1
Total Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.113	< 0.001	10
M+P Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.010	< 0.001	10 ⁽³⁾
O-Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.025	< 0.001	< 0.001	< 0.001	0.102	< 0.001	10 ⁽³⁾
Tetrachloroethene (PCE)	< 0.001	< 0.001	0.0020	0.0060	0.0014	0.0032	0.0040	0.0060	0.0066	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.005
Trichloroethene (TCE)	< 0.001	< 0.001	< 0.001	0.0020	< 0.001	< 0.001	< 0.001	0.0011	0.0016	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.005
Toluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0016	< 0.001	1.0
Cyanide (Total)	< 0.005	< 0.005	< 0.005	0.061	NM	< 0.005	< 0.005	0.033	< 0.005	< 0.005	< 0.005	< 0.005	6.7	0.013	0.2
Chemical Oxygen Demand (COD)	3	7	9	5	NM	7	4	4	5	2	7	9	43	4	NA

Concentrations are in mg/L, except as indicated.

NM = not measured

(1) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) MCL is for Total Xylenes

Values in **bold** exceed the MCL.

**TABLE 4-2. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR THE JUNE 2012 SAMPLING EVENT**

Parameter	June 2012 Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				MCL ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
pH (s.u.)	8 / 8	6.9	7.09	7.1	7.4	HL-90-2	4 / 4	7.15	7.15	7.4	NA
Specific Conductance (µmhos/cm)	8 / 8	702	1223.0	1215	1880	EPA-1	4 / 4	1429.5	994.5	2830	NA
Sulfate	8 / 8	40	145.0	150	200	MPC-1	4 / 4	219.0	110.5	590	NA
Chloride	8 / 8	28	<u>80.8</u>	<u>64.5</u>	150	EPA-1	4 / 4	38.5	34	56	NA
Nitrate+Nitrite as N	8 / 8	1.05	9.10	9.46	16.1	EPA-1	4 / 4	12.053	6.245	31.7	10
Arsenic (Dissolved)	0 / 8	< 0.005	< 0.005	< 0.005	< 0.005	NA	1 / 4	0.0065	< 0.005	0.011	0.010
Iron (Dissolved)	1 / 8	< 0.03	0.0313	< 0.03	0.04	HL-99-3	1 / 4	0.3875	< 0.03	1.46	0.3 ⁽⁶⁾
Nickel (Dissolved)	1 / 8	< 0.01	<u>0.0125</u>	< 0.01	<u>0.03</u>	EPA-1	1 / 4	0.01	< 0.01	0.01	0.10
Selenium (Dissolved)	0 / 8	< 0.001	< 0.0045	< 0.005	< 0.005	NA	1 / 4	0.0063	< 0.005	0.010	0.05
Zinc (Dissolved)	1 / 8	< 0.01	<u>0.0125</u>	< 0.01	0.03	HL-99-3	0 / 4	< 0.01	< 0.01	< 0.01	2.0
1,1,1-Trichloroethane	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.0011	< 0.001	0.0014	0.2
1,1-Dichloroethane	4 / 9	< 0.001	<u>0.0017</u>	< 0.001	<u>0.003</u>	HL-99-3	0 / 4	< 0.001	< 0.001	< 0.001	NA
Benzene	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.1358	< 0.001	0.54	0.005
Bromodichloromethane	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.0014	< 0.001	0.0025	0.010
Chloroform	5 / 9	< 0.001	0.0017	0.0015	0.0043	HL-90-3	4 / 4	0.0067	0.0038	0.017	0.07
Cis-1,2-Dichloroethene	4 / 9	< 0.001	<u>0.0015</u>	< 0.001	<u>0.0039</u>	MPC-1	0 / 4	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	2 / 9	< 0.001	<u>0.0011</u>	< 0.001	0.0014	HL-10-1	0 / 4	< 0.001	< 0.001	< 0.001	1
Total Xylene	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.029	< 0.001	0.113	10
M+P Xylene	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.0033	< 0.001	0.010	10 ⁽⁷⁾
O-Xylene	0 / 9	< 0.001	< 0.0037	< 0.001	< 0.025	NA	1 / 4	0.0263	< 0.001	0.102	10 ⁽⁷⁾
Tetrachloroethene (PCE)	7 / 9	< 0.001	<u>0.0035</u>	<u>0.0032</u>	0.0066	HL-10-1	0 / 4	< 0.001	< 0.001	< 0.001	0.005
Trichloroethene (TCE)	3 / 9	< 0.001	<u>0.0012</u>	< 0.001	<u>0.002</u>	MPC-1	0 / 4	< 0.001	< 0.001	< 0.001	0.005
Toluene	0 / 9	< 0.001	< 0.001	< 0.001	< 0.001	NA	1 / 4	0.0012	< 0.001	0.0016	1.0
Cyanide (Total)	2 / 8	< 0.005	0.016	< 0.005	<u>0.061</u>	MPC-1	1 / 4	1.68	< 0.005	6.7	0.2
Chemical Oxygen Demand (COD)	8 / 8	3	5.50	5	9	EPA-1	4 / 4	15.25	8	43	NA

(1) Downgradient wells are: HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3, HL-10-1.

(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1R, HL-94-2R.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

**TABLE 4-3. COMPARISON OF DOWNGRAIDENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR ALL SAMPLING EVENTS TO DATE**

Parameter	Period of Record Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				MCL ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
pH (s.u.)	263 / 263	6.8	7.42	7.4	8.1	HL-90-2	133 / 133	7.45	7.5	8.1	NA
Specific Conductance (µmhos/cm)	253 / 253	632	1071.8	1010	2550	EPA-1	129 / 129	1382.4	1000	4170	NA
Sulfate	262 / 263	< 15	138.1	132	345	EPA-1	133 / 133	271.7	98	1980	NA
Chloride	263 / 263	2	57.08	44	<u>262</u>	EPA-1	132 / 133	44.92	28	250	NA
Nitrate+Nitrite as N	240 / 242	< 0.05	7.48	7.84	16.9	EPA-1	128 / 128	10.926	6.86	73	10
Arsenic (Dissolved)	6 / 263	< 0.005	0.0052	< 0.005	0.028	MPC-2	50 / 136	0.0068	< 0.005	0.1	0.010
Iron (Dissolved)	61 / 263	< 0.03	0.080	< 0.03	1.69	MPC-1	46 / 133	0.320	< 0.03	3.14	0.3 ⁽⁶⁾
Nickel (Dissolved)	26 / 243	< 0.01	0.011	< 0.01	<u>0.06</u>	EPA-1	23 / 131	0.011	< 0.01	0.05	0.10
Selenium (Dissolved)	5 / 263	< 0.005	0.005	< 0.005	0.006	HL-90-3	40 / 136	0.0056	< 0.005	0.027	0.05
Zinc (Dissolved)	27 / 246	< 0.01	0.0136	< 0.01	0.15	HL-90-2	13 / 131	0.0109	< 0.01	0.10	2.0
1,1,1-Trichloroethane	57 / 387	< 0.0002	0.0012	< 0.001	<u>0.0074</u>	HL-90-1	16 / 140	0.0013	< 0.001	0.0057	0.2
1,1-Dichloroethane	235 / 387	< 0.0006	<u>0.002</u>	<u>0.0014</u>	<u>0.0073</u>	MPC-1	0 / 140	< 0.001	< 0.001	< 0.001	NA
Benzene	2 / 387	< 0.0005	0.001	< 0.001	0.0029	HL-90-2	29 / 140	0.0086	< 0.001	0.54	0.005
Bromodichloromethane	0 / 387	< 0.0005	< 0.001	< 0.001	< 0.002	NA	13 / 140	0.0012	< 0.001	0.0048	0.010
Chloroform	260 / 387	< 0.0003	0.0024	0.0021	0.016	EPA-1	106 / 140	0.0051	0.0028	0.037	0.07
Cis-1,2-Dichloroethene	105 / 364	< 0.0005	<u>0.0013</u>	< 0.001	<u>0.011</u>	EPA-1	0 / 135	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	161 / 387	< 0.0005	<u>0.0016</u>	< 0.001	<u>0.016</u>	EPA-1	0 / 140	< 0.001	< 0.001	< 0.001	1
Total Xylene	1 / 156	< 0.0005	0.001	< 0.001	0.002	MPC-2	12 / 60	0.0061	< 0.001	0.113	10
M+P Xylene	1 / 359	< 0.001	0.001	< 0.001	0.002	HL-99-1	27 / 135	0.0029	< 0.001	0.025	10 ⁽⁷⁾
O-Xylene	3 / 362	< 0.001	0.001	< 0.001	0.002	HL-99-1	29 / 135	0.0039	< 0.001	0.102	10 ⁽⁷⁾
Tetrachloroethene (PCE)	280 / 387	< 0.0005	0.0066	<u>0.0044</u>	0.094	EPA-1	0 / 140	< 0.001	< 0.001	< 0.001	0.005
Trichloroethene (TCE)	161 / 387	< 0.0005	<u>0.0013</u>	< 0.001	0.0074	EPA-1	0 / 140	< 0.001	< 0.001	< 0.001	0.005
Toluene	15 / 387	< 0.0005	0.0011	< 0.001	<u>0.0094</u>	MPC-2	10 / 140	0.0011	< 0.001	0.0046	1.0
Cyanide (Total)	76 / 263	< 0.005	0.0146	< 0.005	0.4	HL-99-2	30 / 135	1.13	< 0.005	10.9	0.2
Chemical Oxygen Demand (COD)	170 / 261	< 0.3	4.2157	3	26	EPA-1	107 / 133	12.6	7	75	NA

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: 83-6, HL-06-1, MPC-5, HL-94-1, HL-94-1R, HL-94-2, HL-94-2R.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

Parameters detected in only downgradient wells include: zinc, 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), and trichloroethene (TCE).

- (b) The parameter historically detected only in background wells (Table 4-3) is bromodichloromethane. Parameters historically detected only in downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE.
- (c) Nitrate, arsenic, iron, benzene, PCE, and cyanide were reported at concentrations exceeding MCL criteria in the June 2012 sampling event (Tables 4-1 and 4-2). The MCL for arsenic was exceeded in a single upgradient well (HL-94-2R); the MCLs for benzene and cyanide were exceeded in a single upgradient well (MPC-5); the MCL for PCE was exceeded in three downgradient wells (HL-10-1, MPC-1 and HL-99-3); nitrate exceeded its MCL in two downgradient wells (EPA-1 and MPC-1), one upgradient well (MPC-5), and cross-gradient well HL-94-3; the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).
- (d) Historically in these wells, nitrate, arsenic, iron, benzene, PCE, TCE, and cyanide have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCLs for PCE and TCE have been exceeded in only downgradient wells; nitrate, arsenic, iron, and cyanide have exceeded their MCLs in both upgradient and downgradient wells; and the MCL for benzene has been exceeded in only upgradient wells. The June 2012 data is generally consistent with these trends with the exception of cyanide.
- (e) Nitrate was detected in all of the June 2012 samples. The MCL of 10.0 mg/L was exceeded in one sample collected in upgradient well (MPC-5) and in two samples collected from downgradient wells (EPA-1 and MPC-1). Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a general decrease in the nitrate concentration in this well and is currently at a level of 31.7 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may

have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse affects became apparent. However, nitrate levels in downgradient wells have slowly been increasing since that time.

- (f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). Arsenic was detected only in upgradient well HL-94-2R; iron was detected in downgradient well HL-99-3 and upgradient well MPC-5; nickel was only detected in downgradient well EPA-1 and upgradient well MPC-5; selenium was only detected in upgradient well MPC-5; and zinc was detected only in downgradient well HL-99-3 during June 2012 monitoring (Table 3-1). The detected arsenic and metal concentrations were all at or near their detection limits except for arsenic in upgradient well HL-94-2R (0.011 mg/L) compared to a detection limit of 0.005 mg/L and iron in upgradient well MPC-5 (1.46 mg/L) compared to a detection limit of 0.03 mg/L. Arsenic exceeded the MCL of 0.01 mg/L in HL-94-2R. Arsenic has historically fluctuated at HL-94-2 with concentrations ranging from <0.005 mg/L to 0.011 mg/L (based on data collected from April 1994 through December 2012). This is the highest concentration of arsenic in this well over the sampling history. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through June 2012).

- (g) During the June 2012 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE). PCE was the only VOC to exceed its MCL in downgradient wells (HL-10-1, MPC-1 and HL-99-3). 1,1,1-trichloroethane, benzene, bromodichloromethane, m+p xylene, o-xylene, total xylene, and toluene were detected only in background wells; benzene was the only VOC to exceed its MCL in upgradient wells (MPC-5). Chloroform was the only VOC detected in samples from

both downgradient and background wells. All detections of chloroform were well below the MCL of 0.07 mg/L.

- (h) Cyanide was detected in two downgradient wells (MPC-1 and HL-99-3) and one upgradient well (MPC-5) during the June 2012 sampling event. All detections were well below the MCL of 0.2 mg/L with the exception of upgradient well MPC-5 (6.7 mg/L). Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through June 2012) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

4.2 INTER-WELL PREDICTION INTERVAL ANALYSIS

An inter-well prediction interval analysis was used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the June 2012 sampling event). Combining all historical data for the background wells, the Shapiro-Francia Test of Normality was performed for each parameter to determine the distribution of the background data. Inter-well parametric prediction intervals were used when the background data were normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at zero. Results of the prediction interval test are summarized in Table 4-4.

TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

Parameter	Background Wells		Downgradient Wells							
	Distribution ⁽¹⁾	Prediction Limit ⁽²⁾	HL-90-2	HL-90-3	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-10-1
pH (s.u.)	Non-Norm	7.97	7.4	7.1	7.1	NM	7	7.2	7.1	6.9
Specific Conductance (µmhos/cm)	Non-Norm	4001	702	1250	1180	NM	1370	966	966	1470
Sulfate	Non-Norm	1697	40	180	200	NM	170	120	150	150
Chloride	Non-Norm	187	28	63	66	NM	100	49	50	140
Nitrate+Nitrite as N	Non-Norm	66.6	1.05	10	11.8	NM	9.62	6.14	8.8	9.3
Arsenic (Dissolved)	Non-Norm	0.029	0.005	0.005	0.005	NM	0.005	0.005	0.005	0.005
Iron (Dissolved)	Non-Norm	2.88	0.03	0.03	0.03	NM	0.03	0.03	0.04	0.03
Selenium (Dissolved)	Non-Norm	0.010	0.005	0.005	0.005	NM	0.005	0.005	0.001	0.005
Zinc (Dissolved)	ND	0.01	0.01	0.01	0.01	NM	0.01	0.01	0.03	0.01
1,1,1-Trichloroethane	Non-Norm	0.0052	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1,1-Dichloroethane	ND	0.001	0.001	0.001	0.0029	0.001	0.001	0.0021	0.003	0.0024
Benzene	Non-Norm	0.072	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bromodichloromethane	Non-Norm	0.0040	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Chloroform	Non-Norm	0.035	0.001	0.0043	0.0018	0.001	0.0019	0.0015	0.0022	0.001
Cis-1,2-Dichloroethene	ND	0.001	0.001	0.001	0.0039	0.001	0.0016	0.001	0.001	0.0022
Dichlorodifluoromethane	ND	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0012	0.0014
Total Xylene	Non-Norm	0.0776	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
O-Xylene	Non-Norm	0.031	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.025
Tetrachloroethene (PCE)	ND	0.001	0.001	0.001	0.006	0.0014	0.0032	0.004	0.006	0.0066
Trichloroethene (TCE)	ND	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.0011	0.0016
Cyanide (Total)	Non-Norm	10.5	0.005	0.005	0.061	NM	0.005	0.005	0.033	0.005
Chemical Oxygen Demand (COD)	Non-Norm	63.4	3	7	5	NM	7	4	4	5

(1) Normality was calculated using the Shapiro-Francia test.

Norm (X%) = data normally distributed at X% level of significance.

ln-Norm (X%) = data ln-normally distributed at X% level of significance.

Non-Norm = data not normally or ln-normally distributed at 95% or 99% level of significance.

ND = all background data below detection limits. Value shown is the detection limit.

(2) Prediction limits calculated as follows:

Normal or ln-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)

Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)

ND: any detectable concentrations in compliance wells are considered significant.

Bold values indicate statistically significant results.

NA - not analyzed

Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, zinc, 1,1-dichloroethane, cis-1,2-dichloroethane, dichlorodifluoromethane, PCE, and TCE have statistically greater concentrations in downgradient wells than upgradient wells.

4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the June 2012 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. Spearman's trend test was used to evaluate parameters related to well HL-10-1 due to the low number of samples available for that well. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The results of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES

Parameter	HL-10-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3
Zinc						Increasing
1,1-Dichloroethane	No Trend	Decreasing			Increasing	No Trend
Cis-1,2-Dichloroethane	No Trend	Increasing		No Trend		
Dichlorodifluoromethane	No Trend					Decreasing
Tetrachloroethene (PCE)	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing
Trichloroethene (TCE)	No Trend	No Trend				No Trend

*Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed.

Zinc is showing an increasing trend in HL-99-3. Cis-1,2-dichloroethane is showing an increasing trend in MPC-1; according to National Primary Drinking Water Regulations, cis-1,2-dichloroethane is formed as a breakdown product from the reductive dehalogenation of

the common industrial solvents TCE and PCE. Dichlorodifluoromethane and PCE are showing decreasing trends in downgradient wells. 1,1-Dichloroethane is showing increasing and decreasing trends in downgradient wells; this compound is a breakdown product of 1,1,1-trichloroethane, historically found primarily in wells upgradient of the Helena landfill.

4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents currently exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2 and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events along with compliance well HL-90-1, now replaced by HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past ten years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-10-1, MPC-1 and HL-99-3 for June 2012.

Historically, the concentration of PCE in well MPC-1 (now 0.006 mg/L) has fluctuated between 0.0032 mg/L and 0.017 mg/L based on data collected between May 1992 and June 2012 and according to the trend analysis discussed in the previous section, is showing neither an increasing or a decreasing trend. The PCE concentrations in pumping wells HL-99-1, HL-99-2 and HL-99-3 have shown seasonal fluctuations and decreasing trends in HL-99-1

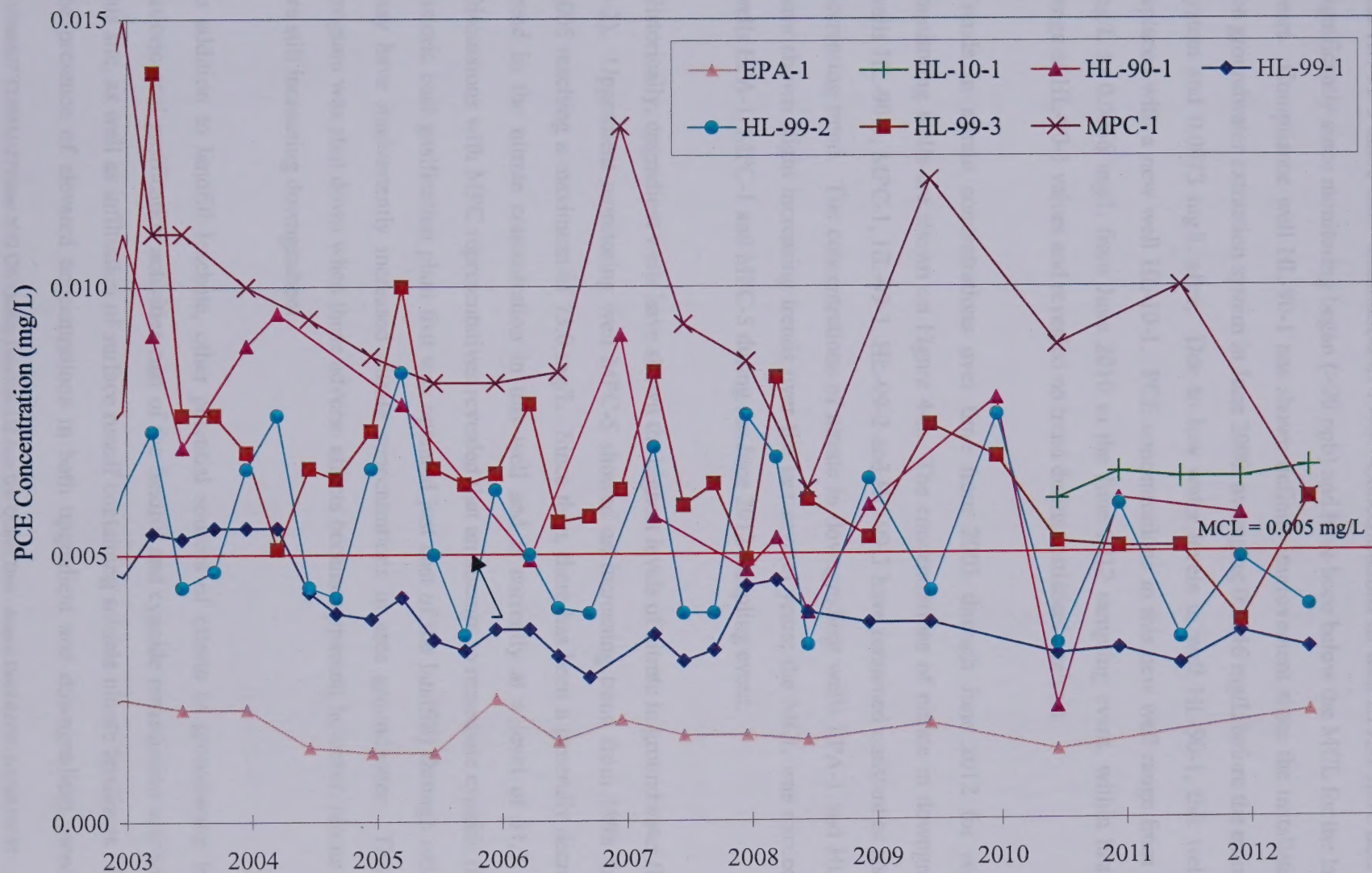


Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells

and HL-99-3 since their installation in 1999. Concentrations in well EPA-1 have decreased significantly since monitoring began (>90 ppb) and have been below the MCL for the last ten years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0073 mg/L after. Due to low water levels in well HL-90-1, this well was replaced with a new well HL-10-1. PCE concentrations in this new well range from 0.006 mg/L to 0.0066 mg/L from June 2010 to the June 2012 sampling event, within historical range of HL-90-1 values and revealed no trend during statistical analysis.

Trends in nitrate concentrations over time from 2003 through June 2012 for selected monitoring wells are shown on Figure 4-2. The concentrations of nitrate in downgradient wells HL-90-3, MPC-1, HL-99-1, HL-99-2 and HL-99-3 have remained constant or shown a decreasing trend. The concentrations of nitrate in downgradient wells EPA-1 and HL-06-1 have shown slight increasing trends over the last several years; the MCL was exceeded in wells EPA-1, MPC-1 and MPC-5 during the June 2012 sampling event.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well and is currently at a level of 31.7 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse affects became apparent; however, nitrate levels are still increasing downgradient.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring

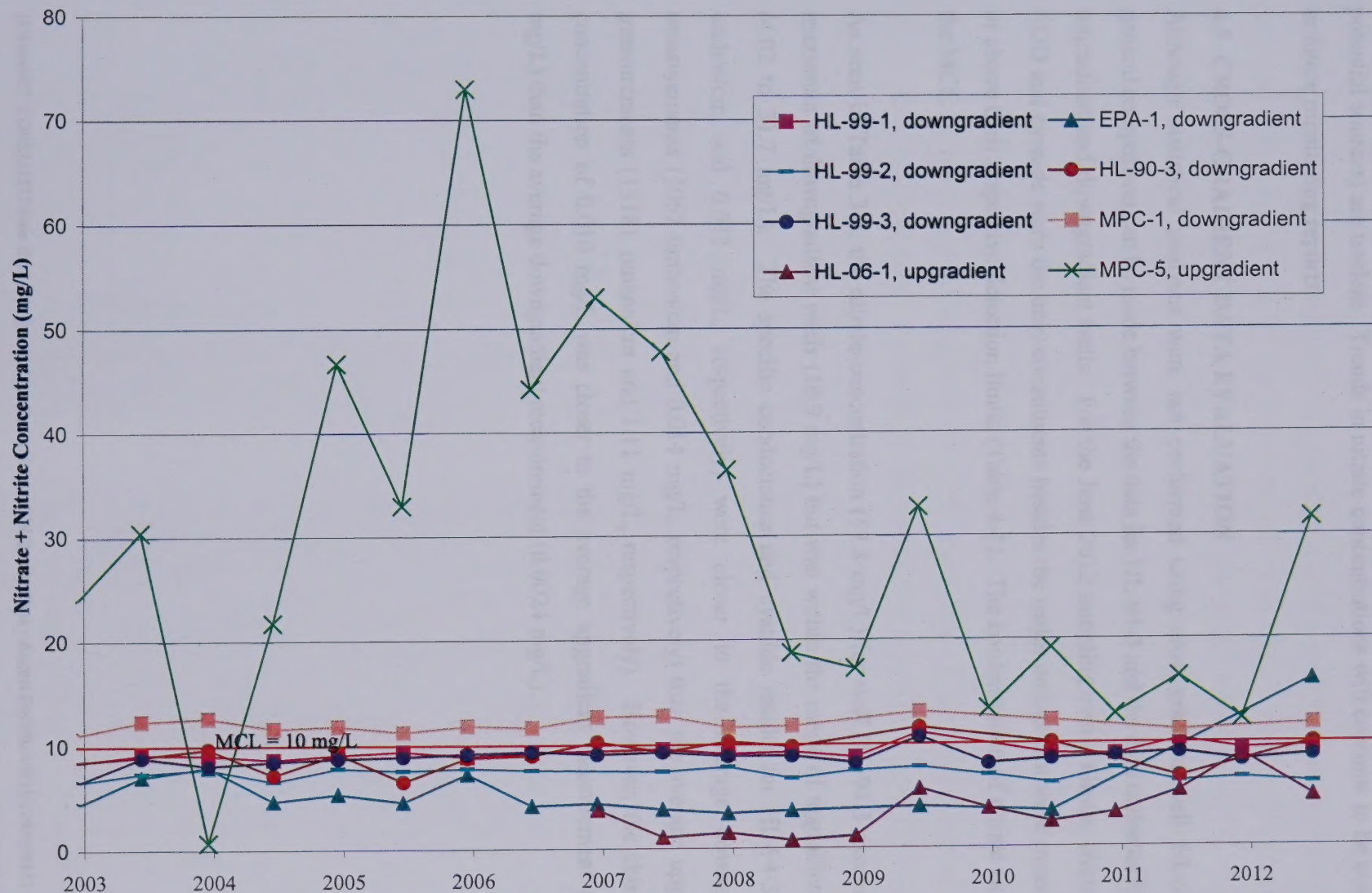


Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells

wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

4.5 CROSS-GRADIENT DATA EVALUATION

Although statistical analyses were not performed using cross-gradient well HL-94-3, a general comparison can be made between the data for HL-94-3 and the data collected for both upgradient and downgradient wells. For the June 2012 sampling event, nitrate, chloroform, COD and cyanide were the only constituents besides the major anions that were measured at or above their respective detection limits (Table 4-1). The concentration of nitrate exceeded the MCL.

As seen in Table 3-2, the nitrate concentration (17.8 mg/L) for well HL-94-3 exceeded the maximum of downgradient wells (16.9 mg/L) but was within the range of upgradient wells (4.02 to 31.7 mg/L). The specific conductance and cyanide results for HL-94-3 (1030 umhos/cm and 0.013 mg/L, respectively) were closer to the average downgradient measurements (1067 umhos/cm and 0.014 mg/L, respectively) than the average upgradient measurements (13181 umhos/cm and 1.11 mg/L, respectively). However, the chloroform concentration of 0.010 mg/L was closer to the average upgradient measurement (0.0051 mg/L) than the average downgradient measurement (0.0024 mg/L).

5. IRRIGATION WELL AND DOMESTIC WELL DATA EVALUATION

One irrigation well, the infiltration gallery and eight domestic wells were also sampled during the June 2012 sampling event. The infiltration gallery and well 62 had no VOCs reported above the detection limits. Well 90 had only a single detectable concentration of chloroform. For wells 5, 16, 40, 48, 52, and 57, the only concentrations of VOCs reported above the detection limit were for chloroform and PCE; all detections were below their respective MCLs. Irrigation well I-4 had measurable concentrations of 1,1-dichloroethane and cis-1,2-dichloroethene in addition to chloroform and PCE. All detections were below the MCLs. Trends in PCE concentrations over the last ten years for the sampled domestic and irrigation wells are shown on Figure 5-1. Wells I-4, 5, 40 and 57 are all showing degreasing trends. All of these wells are used only for irrigation and all homeowners of these domestic wells have been connected to the City water supply.

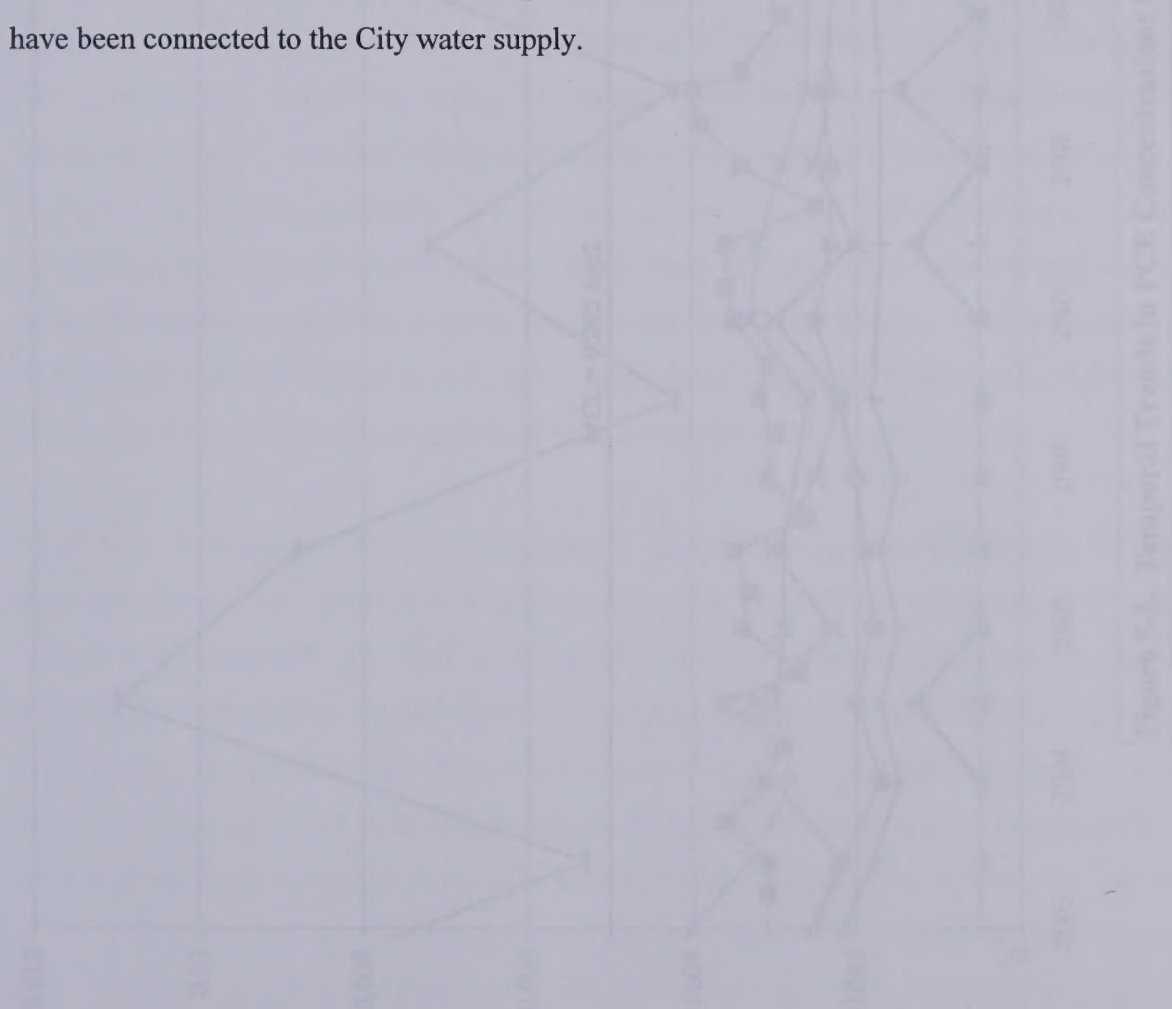




Figure 5-1. Temporal Trends in PCE Concentrations in Domestic and Irrigation Wells

6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the June 2012 sample results indicated that zinc, 1,1-dichloroethene, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE were detected in downgradient wells at levels statistically greater than upgradient wells. PCE and nitrate were the only groundwater constituents that exceeded the primary MCL (federal drinking water standard) in one or more downgradient wells. Exceedances of nitrate and cyanide are likely due to former coal degasification plant sources. The MCLs for nitrate, benzene, and cyanide and the secondary MCL for iron were exceeded in upgradient well MPC-5 and the MCL for arsenic was exceeded in upgradient well HL-94-2R.

Nitrate exceeded the MCL of 10.0 mg/L in one sample collected in upgradient well (MPC-5) and in two samples collected from downgradient wells (EPA-1 and MPC-1). Historically, concentrations of nitrate in upgradient wells have far exceeded concentrations in downgradient wells. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources such as the historic industrial area east of the landfill and commonly used nitrate fertilizers) are unclear. Monitoring of groundwater nitrate concentrations will continue in future semiannual monitoring events, allowing further evaluation of upgradient and downgradient concentration trends.

To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2 and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Statistical evaluations of PCE concentrations in wells HL-99-1 and HL-99-3 show a decreasing trend.

PCE exceeded the federal MCL in downgradient wells HL-10-1, MPC-1 and HL-99-3. According to the potentiometric map in Figure 2-2, groundwater flow through well MPC-1 heads directly for the groundwater extraction and should be extracted and treated. Concentrations of PCE in extraction wells HL-99-1 and HL-99-3 show a statistically decreasing trend. Well HL-10-1 was installed in May 2010 immediately adjacent to but deeper than compliance well HL-90-1. The concentration of PCE in well HL-10-1 is within historical range of HL-90-1 concentrations and near the MCL. PCE concentrations in HL-10-1 should continue to be stable or decreasing as assumed finite upgradient sources are diminished. Downgradient of HL-10-1, irrigation well I-4 and domestic wells 5 and 40 have shown significantly decreasing trends since the installation of the groundwater extraction system.

7. REFERENCES

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DATA VALIDATION REPORT CITY OF KEENE LANDFILL

Report Prepared By: [Redacted]

January 2012

COHELA 1273

APPENDIX A

DATA VALIDATION REPORT

Reported by:
[Redacted]
City of Keene Landfill
[Redacted]

COHELA 1273

DATA VALIDATION REPORT CITY OF HELENA LANDFILL

Groundwater Samples Collected in

**June/July 2012
(Semi-Annual Sampling)**

Prepared by
Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

SEPTEMBER 2012

TABLE OF CONTENTS

LIST OF APPENDICES	II
GLOSSARY OF TERMS	III
SUMMARY	1
1. INTRODUCTION	3
2. DELIVERABLES	4
3. FIELD QUALITY CONTROL SAMPLES.....	4
4. LABORATORY PROCEDURES	5
5. DETECTION LIMITS	5
6. LABORATORY BLANKS	6
7. LABORATORY BLANK SPIKES.....	6
8. SURROGATE SPIKES.....	6
9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD).....	7
10. INTERPARAMETER RELATIONSHIPS.....	7
11. HISTORICAL COMPARISON.....	7
12. DATA QUALITY OBJECTIVES.....	8
REFERENCES	9

LIST OF APPENDICES

APPENDIX 1: TABLES

TABLE 1 – Data Validation Codes and Definitions

TABLE 2 – Historical Comparison

APPENDIX 2: DATABASE

APPENDIX 3: HYDROMETRICS FIELD NOTES

APPENDIX 4: ENERGY LABORATORIES ANALYTICAL REPORT

GLOSSARY OF TERMS

CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CLP	Contract Laboratory Program
CRDL.....	Contract Required Detection Limit
FAA	Flame Atomic Absorption
GFAA	Graphite Furnace Atomic Absorption
HGAA.....	Hydride Generation Atomic Absorption
ICB.....	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICV	Initial Calibration Verification
IDL.....	Instrument Detection Limit
LCS	Laboratory Control Sample
MSA.....	Method of Standard Additions
PB	Preparation Blank
PRDL	Project Required Detection Limit
QAPP	Quality Assurance Project Plan
QC.....	Quality Control
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SOW	Statement of Work
TDS.....	Total Dissolved Solids

SUMMARY

Laboratory analysis for groundwater samples collected for the June/July 2012 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

Violations involving field quality control samples:

- There were no QC violations for any of the field quality control samples.

Violations involving laboratory quality control samples:

- In the QA/QC Summary Reports provided by Energy Laboratories, there were several QA/QC exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.
- It should be noted that for several samples the reporting limit for sulfate and nitrate + nitrite as N, was increased due to sample matrix interference. Also, the laboratory method and reporting limit used for dissolved mercury were changed from method SW6020, reported at <0.001 mg/L, to method SW7470A with a reporting limit of <0.0001.
- Due to a field error, sample number HL-1206-113, was preserved in the laboratory upon receipt for nutrients with 2 ml sulfuric acid to acidify to pH<2. This may have impacted the sample result for nitrate + nitrate as N which was reported at 16.1 mg/L, and is greater than 10 standard deviations from the mean for this parameter.
- For HL-1206-119, the laboratory spike recovery for the surrogate p-Bromofluorobenzene was outside of advisory limits. This may have impacted the reported results for benzene (0.54 mg/L), total xylene (0.113 mg/L), and o-xylene (0.102 mg/L) which were all greater than 10 standard deviations from the mean. Also, o-xylene was qualified by the laboratory with an E, indicating that the result is estimated, as the value exceeds the instrument upper quantitation limit.
- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, and cyanide. However, no associated

data was flagged because the methods used are considered comparable to stated methods in the work plan.

- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted “immediately”, but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 100 percent of the field quality control sample results were within control limits and 97 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; and a historical comparison is in Table 2. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field Notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

DATA VALIDATION REPORT

1. INTRODUCTION

This validation applies to organic and inorganic analyses for 28 water samples collected for the City of Helena Landfill semi-annual monitoring project during the June and July 2012 sampling event. The total number of samples included: one field duplicate, two field blanks (DI and Rinsate) and one trip blank.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

SITE CODE	SAMPLE NUMBER	WATER LEVEL	FIELD PARAMETERS ¹	METALS AND COMMONS ²	VOLATILES METHOD 8260 ³
INF GALLERY	HL-1206-100	X	X		X
MPC-2	HL-1206-101	X	X		X
#90	HL-1206-118		X		X
Rinsate Blank	HL-1206-125			X	X
D.I. Blank	HL-1206-126			X	X
MPC-5	HL-1206-119	X	X	X	X
#52	HL-1206-121		X		X
I-4	HL-1206-120		X		X
#5	HL-1206-122		X		X
HL-99-2	HL-1206-124	X	X	X	X
HL-99-1	HL-1206-123	X	X	X	X
HL-90-2	HL-1206-102	X	X	X	X
HL-06-1	HL-1206-105	X	X	X	X
HL-90-3	HL-1206-106	X	X	X	X
HL-90-3 DUP	HL-1206-107			X	X
HL-94-1R	HL-1206-103	X	X	X	X
HL-94-2R	HL-1206-108	X	X	X	X
HL-94-3	HL-1206-104	X	X	X	X
HL-90-1	HL-1206-131	X			
#57	HL-1206-112		X	X	X
MPC-1	HL-1206-111	X	X	X	X
EPA-1	HL-1206-113	X	X	X	X
#62	HL-1206-114		X		X
#48	HL-1206-115		X		X
HL-10-01	HL-1206-109	X	X	X	X
#16	HL-1206-116		X		X
HL-99-3	HL-1206-117	X	X	X	X
#40	HL-1206-110		X		X
TRIP BLANK	TP 6/19/12 EM				X
HL-99-3	HL-1206-128	X	X	X	X

- 1.) Field parameters include pH, SC, and water temperature.
- 2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.
- 3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:

(Check all that apply)

- ☒ EPA CLP National Functional Guidelines for Inorganics Data Review
- ☒ EPA CLP National Functional Guidelines for Organic Data Review
- ☒ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)

- Overall level of validation:

- ☐ Contract Laboratory Program (CLP)
- ☒ Standard (see following Notes)
- ☐ Visual

Notes: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.

☒ Yes (see following Notes)
☐ No

- All documentation of field procedures was provided as required.

☒ Yes
☐ No

- Consistency with project requirements

Sampling was completed in order as stated in the SAP.

☒ Yes (see following Notes)
☐ No

Notes: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

3. FIELD QUALITY CONTROL SAMPLES

- **Field blanks**

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

DI, trip, rinsate, or any other field blanks have been carried out at the proper frequency.

☒ Yes
☐ No

Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

☒ Yes
☐ No

- **Field duplicates**

Field duplicates have been collected at the proper frequency.

☒ Yes
☐ No

Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within $\pm$ the PRDL for water matrix, within $\pm$ 2 times the PRDL for soil matrix.

☒ Yes
☐ No

- **Field standards**

Field standards were sent at the proper frequency

☐ Yes
☐ No

☒ NA - Not required by the work plan.

4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

☐ CLP-SOW

☒ SW-846

☒ Methods for Chemical Analysis of Water and Wastes

☐ XRF Standard Operating Procedures

☐ Other

- **Samples were received by the laboratory at the proper temperature**

☒ Yes
☐ No

- **Holding times met**

☐ Yes

☒ No (see the following Notes)

Notes: Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.

- **Consistency with project requirements**

Analyses were carried out as requested.

☒ Yes (see following Notes)

☐ No

Project specified methods were used.

☒ Yes (see following Notes)

☐ No

Notes: The laboratory method used for dissolved mercury was changed from method SW6020, to method SW7470A.

5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).
☒ Yes (see following Notes)
☐ No

Notes: It should be noted that for several samples the reporting limit for sulfate and nitrate + nitrite as N, was increased due to sample matrix interference. Also, the laboratory reporting limit used for dissolved mercury was changed from <0.001 mg/L, to <0.0001.

6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

Preparation/Method blanks were prepared and analyzed at the required frequency.

☒ Yes
☐ No

All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).

☒ Yes
☐ No

7. LABORATORY BLANK SPIKES

- **Blank Spikes**

Blank spikes (organics) were prepared and analyzed at the required frequency.

☒ Yes
☐ No

Blank spike recoveries were within control limits.

☒ Yes
☐ No

8. SURROGATE SPIKES

- **Surrogate Spikes**

Surrogate spikes were prepared and analyzed at the required frequency.

☒ Yes
☐ No

Surrogate spike recoveries were within control limits.

☐ Yes
☒ No (see following Notes)

Notes: For HL-1206-119, the laboratory spike recovery for the surrogate p-Bromofluorobenzene was outside of advisory limits. This may have impacted the reported results for benzene (0.54 mg/L), total xylene (0.113 mg/L), and o-xylene (0.102 mg/L) which were all greater than 10 standard deviations from the mean. Also,

o-xylene was qualified by the laboratory with an E, indicating that the result is estimated, as the value exceeds the instrument upper quantitation limit.

9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike recoveries were within control limits.

☐ Yes

☒ No (see following Notes)

NOTES: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

- Matrix spike duplicate samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike duplicate RPD's were within control limits.

☐ Yes

☒ No (see following Notes)

NOTES: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from the June 2012 monitoring:

☒ Lab SC versus field SC

☒ Lab pH versus field pH

Lab SC versus field SC: A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

Lab pH versus field pH: A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

11. HISTORICAL COMPARISON

Current sampling event data (June/July 2012) were compared to historical data (June 2008 through May 2012). The data for the June 2012 sampling event compared well to the historic data.

12. DATA QUALITY OBJECTIVES

- Project data quality objectives (DQO's) met.

X Yes

 No

Accuracy

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

Precision

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 97 percent for this sampling event.

Field precision was 100 percent for this sampling event.

Completeness

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

DATA VALIDATION REPORT

Prepared by: Jennifer Vanek

Reviewed by: Jodi Bingham, P.E.

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APPENDIX B

STATISTICAL ANALYSIS REPORTS

